December 13, 1894.

Sir JOHN EVANS, K.C.B., D.C.L., LL.D., Vice-President and Treasurer, in the Chair.

A List of the Presents received was laid on the table, and thanks ordered for them.

The following Papers were read :—

I. "On the Photographic Spectrum of γ-Cassiopeiæ." By J. NORMAN LOCKYER, C.B., F.R.S. Received November 19, 1894.

Introductory.

In the Bakerian Lecture for 1888* I referred in some detail to the spectrum of γ-Cassiopeiæ, and suggested explanations of the origins of the various lines which had been observed. At that time no photographs of the spectrum were available for discussion, but the questions raised by the eye observations were of such great interest that I determined to attempt a photographic study of the spectrum. This was commenced in November, 1888, and has been continued at intervals up to the present time.

In view of the somewhat conflicting evidence of the variability of the spectrum, it was considered necessary that the photographs should extend over a considerable period before any serious attempt was made to discuss them. Some of the results obtained, however, now appear to be so definite that I have thought it desirable to communicate them to the Society at once. I therefore give particulars of the inquiry so far as it has yet gone, and a brief account of other observations is added, in order that the significance of the photographic results may be the better realised.

In the paper referred to I gave an historical statement including the early observations ; it is only necessary to add to this that the spectrum has been since observed or photographed by Professor E. C. Pickering, Professor Keeler, and Dr. Belopolsky.

Professor Pickering makes no mention of dark lines, or of bright lines other than F.†

Professor Keeler, observing with the Lick refractor in 1889‡ failed

* 'Roy. Soc. Proc.,' vol. 44, p. 43.

† 'Draper Catalogue,' p. 266.

‡ 'Publ. Ast. Soc. Pacific,' vol. 1, p. 80.

to see D_3, and gives the following particulars of his observations :—"I have examined it [the spectrum of the star] frequently, but, so far, no changes have been seen. The C and F lines are brilliant, narrow, and sharp. $H\gamma$ in the violet is seen with some difficulty. The green is full of very fine delicate dark lines, seen only under good atmospheric conditions, the *b* group being somewhat more prominent than the others. There is also an appearance of faint bright lines, or perhaps spaces between the fine dark lines just mentioned, seeming bright by contrast. It is difficult to decide on this point. There are in all eight or ten such places. Somewhat nearer to C than to the estimated position of D is a fairly prominent dark band, or, more probably, group of fine lines. Not the slightest trace of bright or dark lines can be seen in the vicinity of D. The continuous spectrum close to the bright hydrogen lines appears somewhat darker than it does elsewhere, but this I have considered to be the effect of contrast."

Professor Keeler has since succeeded in photographing dark lines in the spectrum.*

Belopolsky states that D_3 did not appear in three photographs of the spectrum taken by him in 1892.†

It may also be stated that the spectrum of this star has been occasionally shown to students at Kensington since 1886, and the bright lines C and F have always been visible. Four dates are recorded in the note-books, namely, September 18, October 13 and October 24, 1889, and October 21, 1894. The presence of bright D_3, as well as of C and F, was noted on all these dates, except October 24, 1889.

Dr. Copeland has been good enough to communicate to me an unpublished observation made at Dunecht on September 13, 1885. C was then very bright, F just measurable, while D_3 could not be made out with certainty. This observation was made with the 15-in. refractor.

It appears, therefore, that D_3, and possibly also the bright lines of hydrogen, may be of variable intensity, but it does not seem possible to lay down any law connecting the changes.

The Kensington Photographs.

The first photograph obtained at Kensington was taken on November 20, 1888, and since then fifty-three photographs have been secured. The instruments employed were those described in my recent paper on "The Photographic Spectra of some of the Brighter

* 'Astronomical Spectroscopy,' Frost's translation, p. 249.

† 'Ast. and Ast. Phys.,' 1893, p. 259.

Stars."* A complete list of the photographs is given in the following table.

Date.	Instrument employed.	Date.	Instrument employed.
1888. Nov. 20	A	1892. May 10	B
„ 21	„	„ 18	„
1891. Jan. 14	C	June 27	„
„ 22	„	„ 29	„
Mar. 3	„	July 4	„
July 17	„	July 22	„
Sept. 9	„	Sept. 5	„
„ 14	A	„ 14	„
„ 15	C	Oct. 18	„
Oct. 2	A	1893. Aug. 8	„
„ 3	„	„ 17	„
„ 7	„	„ 22	„
„ 9	„	„ 25	„
„ 12	„	„ 28	„
„ 15	„	Sept. 4	„
„ 17	„	„ 7	„
„ 20	„	Oct. 6	„
„ 23	„	„ 26	„
„ 28	„	Dec. 14	„
„ 30	„	„ 21	„
Nov. 9	„	1894. Jan. 12	„
„ 11	„	„ 18	„
„ 30	„	Oct. 16	„
Dec. 2	„	Nov. 6	„
1892. Jan. 1	„	„ 15	„
„ 3	„	„ 16	„
„ 8	„		

Results of the Preliminary Discussion.

(1) *All the photographs taken at Kensington show bright lines of hydrogen.*

The lines Hβ, Hγ, and Hδ are constantly seen, and Hε and Hζ appear when the photographic conditions have been good. This suggests that their apparent absence, noted by some observers in the period 1874 to 1883, was possibly due to imperfect conditions of observation.

(2) *In addition to the bright lines of hydrogen, there are other bright lines in the spectrum.*

The additional bright lines appear in all good negatives; in cases of under or over exposure, or when other conditions have affected the quality of the negative, they are not distinctly seen.

For the most part, these lines are ill-defined; their positions, therefore, cannot be determined with any great degree of accuracy.

* 'Phil. Trans.,' A, 1893, vol. 184, p. 678.

The wave-lengths of some of these lines may also require correction for displacement due to motion in the line of sight, when the conditions have been more fully investigated. Attention may be specially directed to two lines at 4384 and 4465; in the spectrum of β-Lyræ there are two bright lines with the normal positions 4388 and 4471, agreeing in position with prominent lines in the spectra of stars of Group IIIγ,* and it seems possible that we have to deal with the same lines in γ-Cassiopeiæ. This is rendered more probable by the fact, which will appear later, that the two lines in question appear as bright fringes on the more refrangible sides of dark lines, having the wave-lengths 4388 and 4471.

(3) *During the period covered by the photographs there is no evidence of any change in the intensities of the principal bright lines.*

(4) *The bright lines of hydrogen are double in all the photographs taken with sufficient dispersion.*

The series of twenty-six photographs, showing the duplicity of the hydrogen lines, was taken with the 6-in. prism of 45°, and extends from May 18, 1892, to November 16, 1894.

Hγ and Hδ usually show the doubling best, but in some of the photographs Hζ is also clearly seen to be double. The doubling is not so clearly seen at Hϵ, probably owing to the presence of other lines near the same wave-length. The double lines are somewhat diffused at both edges.

(5) *There is no evidence of orbital movement during the period which has elapsed since May*, 1892.

Careful measurements of the distance between the two bright lines at Hγ and Hδ have been made by Mr. D. Baxandall, and it was found that the distances are constant, within the limits of accuracy in measurement.

(6) *Assuming the presence of two sources of bright hydrogen lines, the relative velocity in the line of sight is about* 115 *miles per second.*

This velocity has been deduced from measures of the separation of the lines at Hγ and Hδ in the photographs taken with the 6-in. prism of 45°.

(7) *The bright lines of hydrogen are superposed on broad dark bands.*

This was noted in the earliest photographs, and is fully confirmed by those subsequently obtained. Hβ, Hγ, and Hδ exhibit this feature prominently, but the same is occasionally seen at Hϵ and Hζ. It has also been noted that C presented the same characteristic when observed by Messrs. Fowler and Shackleton on October 21, 1894. The borders of these dark bands are all ill-defined, but they appear to be symmetrically placed with regard to the bright lines. The dark bands are from 10 to 12 tenth-metres broad.

* 'Phil. Trans.,' A, vol. 184, p. 725.

(8) *Besides the dark bands in the positions of the hydrogen lines, there are other ill-defined dark lines.*

The additional dark lines are seen in all good negatives, whether taken with high or low dispersion, but their haziness makes their positions difficult to determine with accuracy. The approximate wave-lengths of the principal dark lines are 3887, 3968, 3994, 4008, 4025, 4069, 4101, 4119, 4143, 4168, 4340, 4388, 4471, 4643, 4860. This at once contradicts Professor Scheiner's recent statement* that he "does not believe it possible that dark lines can exist in the spectrum."

(9) *The dark lines in the spectrum of γ-Cassiopeiæ correspond very closely with the lines seen in the spectra of ζ- and γ-Orionis.*

This fact was recognised at an early stage of the inquiry, and the similarity is shown by the accompanying enlargements. The resemblance is further shown by the appended table, the wave-lengths of the lines in the spectra of ζ- and γ-Orionis being taken from a former communication.†

Dark lines in γ-Cassiopeiæ.	Dark lines in ζ-Orionis.	Dark lines in γ-Orionis.	Remarks.
3887 (5)	3887 (5)	3887 (5)	Hζ
3968 (6)	3968 (6)	3968 (6)	Hε
3994 (1)	3994 (2)	3994 (3)	
4008 (3)	4008 (2)	4008 (5)	
4025 (5)	4025 (4)	4025 (6)	
4069 (3)	4069 (2)	4069 (2)	
4101 (6)	4101 (6)	4101 (6)	Hδ
4119 (1)	—	4119 (2)	
4143 (3)	4143 (2)	4143 (5)	
4168 (2)	—	4168 (3)	
4340 (6)	4340 (6)	4340 (6)	Hγ
4388 (4)	4388 (2)	4388 (5)	
4471 (5)	4471 (5)	4471 (6)	
4643 (2)	—	4643 (2)	
4860 (6)	4860 (6)	4860 (6)	Hβ

The numbers following the wave-lengths refer to the estimated intensities of the lines, 6 representing the strongest lines.

The photographs have been taken at different times by Messrs. Fowler, Baxandall, Shackleton, North, Fournier, and Butler.

Mr. Fowler has also assisted in the preparation of the present preliminary communication.

* 'Astronomical Spectroscopy,' Frost's translation, 1894, p. viii.

† 'Phil. Trans.,' vol. 184, A, pp. 693, 695.